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Relation between the size of the above-ground and the underground phytomass of plant communities in the region of Gurwan-Turuu in Central Mongolia

JAN MAREK MATUSZKIEWICZ, EWA MARIA ROO-ZIELIŃSKA, JERZY SOLON

Institute of Geography and Spatial Organization, Polish Academy of Sciences, Krakowskie Przedmieście 30, 00-927 Warszawa, Poland

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Abstract

Results are presented of measurement of the above-ground and underground phytomass in six different plant communities on the area of the dry steppes of Central Mongolia. The relation was calculated between the above-ground and underground phytomass. This relation was found to be mostly constant under the local conditions (1 : 34). This allows to adopt the "top/roots ratio" as a synthetic index of the vegetation structure in the aspect of zonal differentiation.

INTRODUCTION

Investigation of the ratio of the amount of the above-ground phytomass to the underground one in steppe ecosystems is an interesting ecological problem, since on arid areas the influence of climatic conditions on the value of this proportion is distinctly observable (W a l t e r 1968, 1976). The results of up-to-date investigations on this problem (N u m a t a 1979) allow the assumption that the top/roots ratio may constitute a synthetic index of zonal differentiation of the vegetation on steppe and desert areas. The present study was undertaken to check the above mentioned assumption under the conditions of the but little known so far region of Central Mongolia.

CHARACTERISTIC OF THE TERRAIN AND THE SAMPLING SITES

The Gurwan-Turuu area (107° E longitude, 47°10′ N latitude) lies in the zone of contact between the Khangai-Khantei fold massif and the Khalkhas plain. From the point of view of geobotanical regionalisa-

tion the studied area is included in the central Khalkhas Steppe region in the Dahur-Mongolia steppe province (Grubov 1955, Junatov 1950) and lies in the southern subzone of the dry steppe zone (Junatov 1950, 1952) (Fig. 1). The precipitation amount in the Gurwan-Turuu region is evaluated as about 230 mm annually, consisting in 90 per cent of summer rainfall (Fig. 1).

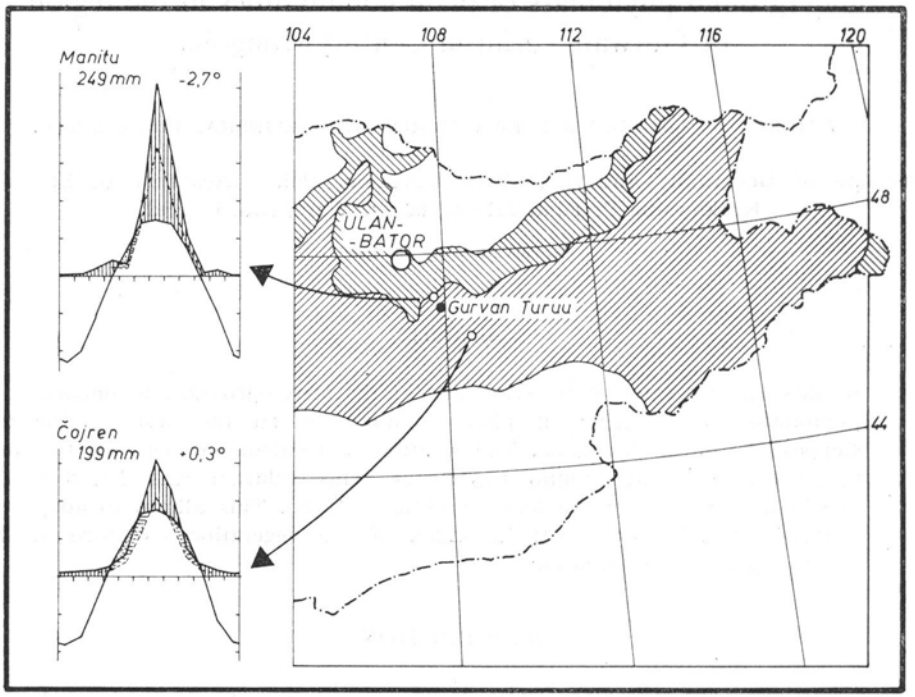

Fig. 1. Situation of the investigated Gurwan-Turuu area within the zone of dry steppes of eastern Mongolia (the northern and southern variant of this zone are distinguished after Junatov 1952). The climatic conditions are characterised by climatic diagrams according to Walter in localities closest to the investigated area (data from Miroshnichenko 1975)

Measurements of the plant biomass were performed on six sites situated on various types of geological substratum: 1 and 2 — diluvial formations, 3 — bazalt, 4 and 5 — granite, 6 — diabase. The five sites represent different varieties of steppe communities on chestnut soils, one (no. 6) is a pasture on continuously humid salty soil near a periodical small lake. Sites 1-4 lie on a treeless steppe. The dominant species are here: *Cleistogenes squarrosa, Stipa krylovii, Aneurolepidium pseudo-agropyrum* (= *Leymus chinensis*), *Allium bidentatum, Artemisia adamsii, Caragana pygmaea* and others. Site 5 represents steppes with a large proportion of the low shrub (25-40 cm high) *Caragana microphylla.*

Community no. 6 is floristically distinctly different from the steppe communities. The main plant species here are: *Carex enervis, Iris biglumis, Potentilla anserina, Halerpestes ruthenica, H. salsuginosa.*

METHODS

The above-ground and underground phytomasses were determined in July and August 1979. The above-ground phytomass was determined in a state close to the annual maximum.

The above-ground and underground phytomasses were determined in plots (1×1 m) randomly distributed. The shoots standing above the ground, both green and yellow, were separated from the plant parts lying on the ground (called lying phytomass). On site 5 the state of the above-ground phytomass was determined on the basis of independent samples from surfaces not overgrown with shrubs (analogously as on other sites) and within clusters of *Caragana microphylla* shrubs (5 plots 0.25 m² each). Then the average state of the phytomass was calculated, taking into account that in this type of steppe clusters of *C. microphylla* shrubs occupy (as established by measurement) on the average 20 per cent of the territory.

The underground parts of plants were collected from four horizons: 0-5, 5-20, 20-40 and 40-60 cm. Two samples were taken from each horizon by cutting soil blocks 15×30 cm through the whole thickness of the given layer. The roots and underground shoots were washed with water and placed on seeves.

The plant material was dried at 105°C and weighed. Mean values were calculated for the sampling sites per 1 m². Further mean values were calculated for the particular phytomass parts on all the sites as well as the variability coefficients ($V = S + \bar{x} \cdot 100\%$).

RESULTS

The underground phytomass of the plant communities ranged from 2000 to 5000 g/m² (mean ca. 3400 g/m²) and the variability coefficient between communities reached values exceeding 70 per cent. In all cases the largest part of the plant biomass was situated in the shallow subsurface layer (Fig. 2). This was most pronounced in the pasture community with *Carex enervis* and *Iris biglumis* where the sward is compact. With increasing depth the amount of plant biomass decreases markedly. The variability between the particular communities also diminished up to a depth of 20-40 cm. The variability coefficient increases once more in the 40-60 cm layer owing to differences in the substrate. In com-

munities lying on fine-grained formations (nos 1 and 4) roots are relatively less numerous in the deeper soil layers than in communities situated on rocky substratum (nos 3 and 5). The amount of above-ground phytomass of the studied communities is more variable (variability coefficient almost 140%) than that of the underground phytomass, ranging from about 100 to 360 g/m² (mean 160 g/m²). This includes the standing phytomass reaching at the state of maximal annual values about 60 to 160 g/m² (mean 103 g/m², variability coefficient ca. 100%). The amount of lying phytomass shows still wider differences between the communities (variability coefficient almost 270%), this being caused by the specific nature of the two communities. On the steppe with *Caragana microphylla* large amounts of plant remnants accumulate within the shrub clusters (more than 700 g/m²), whereas in the pasture community with *Carex enervis* there is hardly any litter in the middle of the vegetation season.

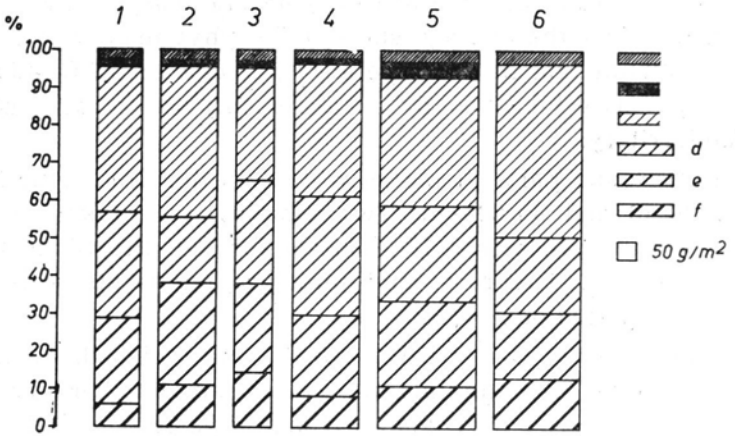

Fig. 2. Percentual proportion of the parts of the phytomass: standing above-ground — a, lying on the ground (litter) — b, underground 0-5 cm — c, underground 5-20 cm — d, underground 20-40 cm — e, underground 40-60 cm — f. 1-6 nos of sampling sites

In contrast to the wide differences in the absolute amounts of phytomass between the communities, the relation between the above- and underground phytomass in these communities is constant (Fig. 3). The top/roots ratio shows only a small variability (variability coefficient below 13%) amounting on the average to 0.029 that is 1:33.9. It was found that in the steppe communities (that is all except no. 6) there is a distinct correlation between the top/roots ratio and the capillary water capacity of the soil (Fig. 4). On soils where it is higher, which in arid climate suffer greater losses of water than the permeable soils, the proportion between the above- and underground phytomass shows lower

values than for soils with low water capacity. This means that on compact soils a higher production of root mass is necessary for the formation of a definite amount of above-ground phytomass as compared with that on permeable soils.

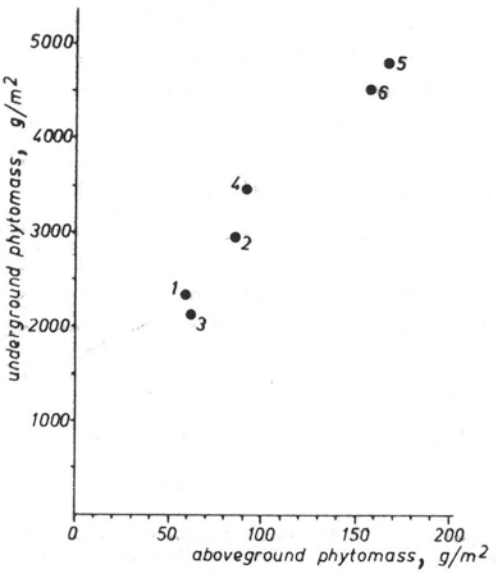

Fig. 3. Relation between above-ground standing and underground phytomass. Nos of sampling sites as in Fig. 2

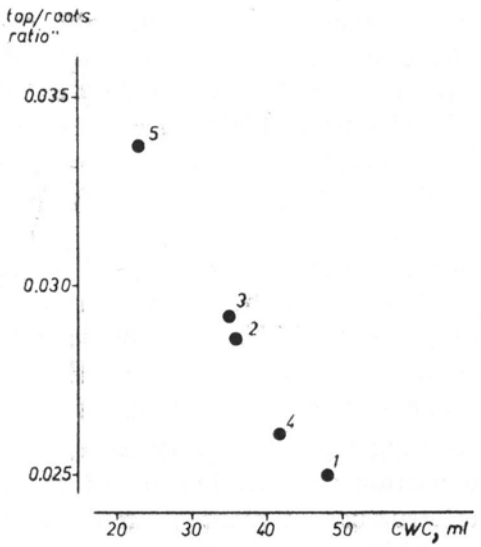

Fig. 4. Dependence of top/root ratio on capillary water capacity of soil (CWC) measured at a depth of 25-35 cm in steppe communities. Nos of sampling sites as in Fig. 2

DISCUSSION

It should be noted that all the plant communities investigated served as pasture for cattle. In the Gurwan-Turuu region the maximal state of the above ground phytomass on the grazed areas was by about 30-40 per cent lower than on surfaces protected from grazing. As established in other regions (Zlotin et al. 1979) grazing increases the underground phytomass therefore the top to roots ratio decreases markedly owing to grazing. Data from the south-Ukrainian steppe (Zlotin et al. 1979) made it possible to calculate that on areas not subjected to grazing this ratio was 0.24, on surfaces moderately exploited by grazing 0.14 and on intensively utilised areas 0.07. This indicates that when data are compared from various regions the intensity of grazing should be taken into account. Under the conditions of Mongolia it may be assumed that grazing is a general and hardly variable factor over centuries, therefore, in not very precise analyses of data from various regions the influence of grazing may be disregarded.

Another factor limiting greatly the generalisation of the results obtained are the wide interseasonal variations of the phytomass of steppe communities (Davazhamc 1974, Gordieyeva 1978). These changes concern mainly the standing above-ground phytomass, but they also involve the underground material. The above- and underground changes are not always correlated. Therefore, measurements in one year give only orientational results, they are, however, necessary in view of the lack of available data for this extensive region.

In other Mongolian regions the top/roots ratio calculated by us on the basis of the available annual measurement data (Banikova 1978, Banikova and Dylis 1978, Davazhamc 1974, Gordieyeva 1977, Miroshnichenko 1967) ranged: in the northern subzone of the dry steppe zone from 1:9 to 1:25, in the southern subzone it was 1:30, whereas in the desert steppe zone or semideserts it varied from 1:30 to 1:119.

A distinct tendency is noticeable, in spite of the nonhomogeneity of the listed data, to a decrease in the top/roots ratio in the plant communities from north to south, that is with diminishing amount of precipitation. The observation in the present studies that this proportion is but little variable under the local conditions with simultaneous finding of the main factor causing local variability (susceptibility of the soil to drought) prove the usefulness of utilisation of the top/roots ratio as characteristic of the structure of plant communities in the analysis of zonal differences in the vegetation. The top/roots ratio amounting to about 1:34 in the southern subzone of the dry steppes zone of Central Asia supplements well the up-to-date data.

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Zależność między wielkością fitomasy nadziemnej i podziemnej zbiorowisk roślinnych w okolicach Gurwan-Turuu w centralnej Mongolii

Streszczenie

Celem niniejszej pracy było zbadanie rozkładu pionowego masy roślinnej zbiorowisk w strefie suchych stepów mongolskich. Badania przeprowadzono na sześciu stanowiskach, z których pięć reprezentowało zbiorowiska stepowe a jedno (nr 6) zbiorowisko wilgotnego pastwiska z *Carex enervis* i *Iris biglumis*. Wśród zbiorowisk stepowych jedno (nr 5) reprezentowało stepy z *Caragana microphylla* (niski, zwarty krzew), a pozostałe różne postacie stepów bezkrzewiastych. Dokonano pomiaru fitomasy stojącej, leżącej (ściółki) oraz podziemnej z czterech kolejnych poziomów.

Stwierdzono, że stosunek fitomasy nadziemnej stojącej do podziemnej ("top/roots ratio") jest wielkością w znacznym stopniu stałą w badanym regionie (średnio

ok. 1:34). Stwierdzono także, że zmienność tej proporcji w różnych zbiorowiskach roślinnych w warunkach lokalnych spowodowana jest przede wszystkim zróżnicowaniem gleb pod względem właściwości fizycznych. Uzyskane wyniki zestawione z danymi z innych regionów stepowych wskazują, że proporcja nadziemnej do podziemnej masy roślinnej zbiorowisk może być traktowana jako syntetyczna charakterystyka roślinności przy rozpatrywaniu zmienności o charakterze strefowym.